RESONANT TRANSFORMER

The equivalent circuit of a single-stage-test transformer along with its capacitive load is shown in Figure 3.5.1 Here $L1$ represents the inductance of the voltage regulator and the transformer primary, L the exciting inductance of the transformer, $L2$ the inductance of the transformer secondary and C the capacitance of the load. Normally inductance L is very large as compared to $L1$ and $L2$ and hence its shunting effect can be neglected. Usually the load capacitance is variable and it is possible that for certain loading, resonance may occur in the circuit suddenly and the Current will then only be limited by the resistance of the circuit and the voltage across the test specimen may go up as high as 20 to 40 times the desired value. Similarly, presence of harmonics due to saturation of iron core of transformer may also result in resonance. Third harmonic frequencies have been found to be quite disastrous. With series resonance, the resonance is controlled at fundamental frequency and hence no unwanted resonance occurs.

The development of series resonance circuit for testing purpose has been very widely welcome by the cable industry as they faced resonance problem with test transformer while testing short lengths of cables. In the initial stages, it was difficult to manufacture continuously variable high voltage and high value reactors to be used in the series circuit and therefore, indirect methods to achieve this objective were employed. Fig. 3.15 shows a continuously variable reactor connected in the low voltage winding of the step up transformer whose secondary is rated for the full test voltage. $C2$ represents the load capacitance. If N is the transformation ratio and L is the inductance on the low voltage side of the transformer, then it is reflected with $N2\ L$ value on the secondary side (load side) of the transformer. For certain setting of the reactor, the inductive reactance may equal the capacitive reactance of the circuit, hence resonance will take place.

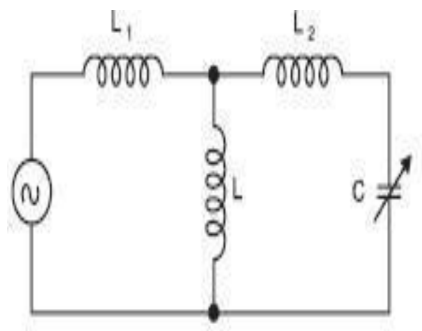

Figure 3.5.1 Equivalent circuit of a single stage loaded transformer

[Source: "High Voltage Engineering" by C.L. Wadhwa , Page – 375]

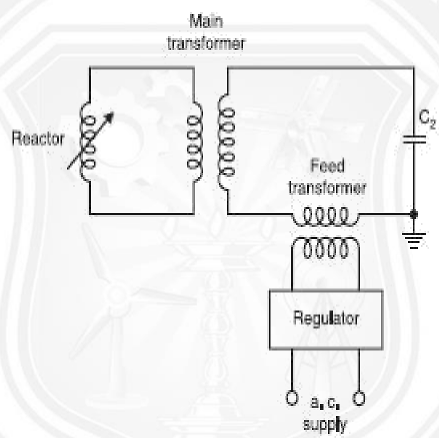

Figure 3.5.2 Single transformer/reactor series resonance circuit

[Source: "High Voltage Engineering" by C.L. Wadhwa , Page – 395]

Thus, the reactive power requirement of the supply becomes zero and it has to supply only the losses of the circuit. However, the transformer has to carry the full load current on the high voltage side. This is a disadvantage of the method. The inductor are designed for high quality factors $Q = \omega L / R$. The feed transformer, therefore, injects the losses of the circuit only. It has now been possible to manufacture high voltage continuously variable reactors 300 kV per unit using a new technique with split iron core. With this, the testing step up transformer can be omitted as shown in Figure 3.5.2. The inductance of these inductors can be varied over a wide range depend upon the capacitance of the load to produce resonance. Here R is usually of low value. After the resonance condition is achieved, the output voltage can be increased by increasing the input voltage.

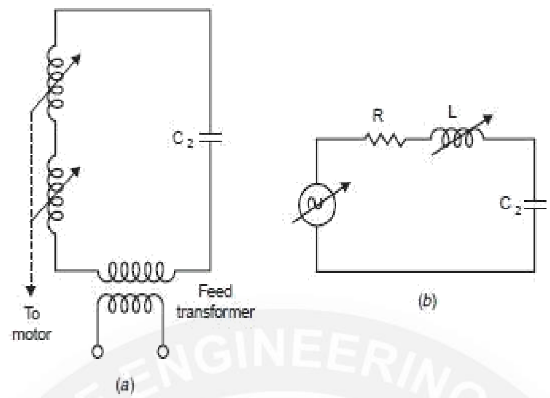

Figure 3.5.3 (a) Series resonance circuit with variable h.t. reactors (b) Equivalent circuit

[Source: "High Voltage Engineering" by C.L. Wadhwa , Page – 405]

Figure 3.5.3 (b) represents an equivalent circuit for series resonance circuit. Here R is usually of low value. After the resonance condition is achieved, the output voltage can be increased by increasing the input voltage. The feed transformers are rated for nominal current ratings of the reactor. Under resonance, the output voltage will be Where Q is the quality factor of the inductor which usually varies between 40 and 80. This means that with Q = 40, the output voltage is 40 times the supply voltage.

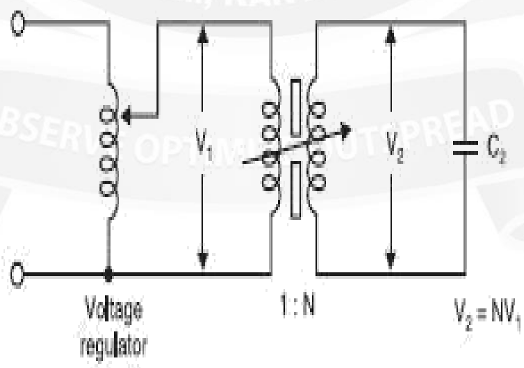

Figure 3.5.4 Parallel resonance system

[Source: "High Voltage Engineering" by C.L. Wadhwa , Page – 415]